MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

ETM7176 – OPTICAL COMMUNICATION SYSTEM

(TE)

11th- March 2019

10.00A.M – 1.00 P.M
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) Describe the three types of refractive index profile in graded-index fiber. Among these three profiles which is the most desirable profile.

[5 marks]

(b) Explain the terms

(i) Normalised frequency

[2 marks]

(ii) Numerical aperture in step-index fiber

[2 marks]

(iii) Numerical aperture in graded-index fiber

[3 marks]

(c)An optical fiber with a radius of $2.5\mu m$ and a refractive-index of 1.45 is surrounded by an air cladding. If the fiber is illuminated by a ray of 1.3 μm light, Determine

(i) Normalised frequency(V)

[2 marks]

(ii) Numerical aperture(NA)

[2 marks]

(iii)An estimate of how many modes can propagate

[2 marks]

(d)A graded index fiber with a core axis refractive index of 1.5 has a characteristic index profile(α) of 1.90 , a relative index difference of 1.3% and a core diameter of$40\mu m$. Estimate the number of guided modes propagating in the fiber when the transmitted light has a wavelength of$1.55\mu m$, and determine the cutoff value of the normalized frequency for single mode transmission in the fiber .

[7 marks]

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Question-2

(a) A GaAs injection laser with refractive index 3.6 has a cavity length of $500\mu m$ and a loss coefficient $20cm^{-1}$ .The measured differential quantum efficiency is 45%. Calculate the internal quantum efficiency of semiconductor laser.

[6 marks]

(b) The equation $\Delta\lambda = \frac{\lambda^2}{2Ln}$, indicates that the refractive index n is independent of wavelength. Where $\Delta\lambda$ is the wavelength spacing.

(i) Show that when n depends on λ ,we have

$$\Delta\lambda = \frac{\lambda^2}{2L\left(n - \lambda\frac{dn}{d\lambda}\right)}$$

[6 marks]

(ii) If the group index $(n - \lambda\frac{dn}{d\lambda})$ is 4.5 for GaAs at 850nm,what is the mode spacing for a $400\mu m$ long laser.

[2 marks]

(c) For laser structures that have strong carrier confinement, thethreshold current density for stimulated emission J_{th} can to a good approximation be related to the lasing – threshold optical gain g_{th} by $g_{th} = \beta J_{th}$, where β is a constant that depends on the specific device construction. Consider a GaAs laser with an optical cavity of length $250\mu m$ and width $100\mu m$ .At the normal operating temperature , the gain factor $\beta = 21\times10^{-3} A/cm^3$ and the effective absorption coefficient $\ddot{\alpha} = 10cm^{-1}$.

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(i) If the refractive index is 3.6,find the threshold current density and the threshold current I_{th} . Assume the laser end faces are uncoated and the current is restricted to the optical cavity.

[5 marks]

(ii) What is the threshold current if the laser cavity width is reduced to $10\mu m$?

[2 marks]

(d) In Light Emitting Diode what do you mean by internal quantum efficiency and External quantum efficiency?

[4 marks]

Question-3

(a) Briefly describe the following terms:

(i) Signal – to – Noise Ratio (SNR)

[3 marks]

(ii) Shot Noise

[3 marks]

(iii) Thermal Noise

[3 marks]

(b) An In GaAs pin photodiode has the following parameters at a wavelength of 1300 nm; $I_D = 4nA, \eta = 0.90, R_L = 1000\Omega$, and the surface leakage current is negligible .The incident optical power is 300nW(-35dBm) , and the receiver bandwidth is 20MHz. Find the various noise terms of the receiver.

[12 marks]

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(c) Give the mathematical explanation of SNR of P-i-N photodiode receiver [7 marks]

Question-4

(a) Write the formula of photon density in terms of width w, thickness d,optical signal power P_s, photons of energy $h\nu$ and group velocity v_g. [3 marks]

(b) Consider an InGaAsP SOA with $w = 5\mu m$ and $d = 0.5\mu m$ .Given that $v_g = 2\times10^8 m/s$,if a $1.0-\mu W$ optical signal at 1550nm enters the device. Calculate the photon density. [7 marks]

(c) The wavelength range for a wavelength-division multiplexed (WDM) system includes the C and L spectral bands , which cover a wavelength range from $1.53\mu m$ to $1.61\mu m$.

(i) How many channels can be transmitted through WDM when the channel spacing is 100GHz? [5 marks]

(ii) What is the spectral efficiency of this WDM system at the bit rate of 10 Gb/s? [3 marks]

(d) Consider an optical soliton transmission system operating at 1550 nm with a dispersion shifted fiber.The optical fiber has a dispersion of 0.5 ps/(nm-km),an effective core area of $50\mu m^2$, and a nonlinear intensity – dependent refractive – index coefficient of $2.6\times10^{-16}\,cm^2/W$ .If the full – width half – maximum (FWHM) of the optical soliton pulse is 20 ps , find the dispersion length and the soliton peak power. [7 marks]

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